Chapter 1: Condition Assessment

Background

The intent of this condition assessment is to independently evaluate the condition of Going-to-the-Sun Road. This assessment includes both a review of what had previously been investigated, concluded, and recommended regarding the conditon of the Road, and an independent field reconnaissance.

One week of field reconnaissance was conducted on the Road in late August, 2000. Field efforts made during this week were successful in providing most of the information necessary to complete this work task. To better define themeans and methods of rehabilitation, this field work will be supplemented in 2001 with a review by helicopter of snow and avalanche conditions in early June, and a second field reconnaissance of the Road in late June.

The field reconnaissance completed to date has resulted in the following general conclusions about the condition of the Road. (These conclusions are also supported by the literature review.)

- Emergency repairs are needed in certain critical areas to keep the Road open and operational in the short term.
- An overall roadway rehabilitation plan is needed to keep the Road open into the future.
- After rehabilitation, a long-term maintenance plan and additional maintenance funding are needed to preserve the Road and prevent it from deteriorating back to its current condition.

More detailed and site-specific observations about the condition of the Road are made in the body of this chapter and in *Chapter 2: Engineering Analysis*.

Going-to-the-Sun Road is a National Historic Landmark. Many of the road features recommended for rehabilitation in this chapter were contributing features in the Road's designation as a Landmark. As such, these features are protected by Federal law and must be preserved by the National Park Service. Throughout this chapter sidebars like this one are used to interject perspectives on the recommendations made for rehabilitation. These perspectives are provided by the authoring team's historic and cultural landscape consultant and are intended to explain what may or may not be acceptable when it comes to the effects of proposed rehabilitation on contributing features.

Going-to-the-Sun Road was originally built in the 1920's and 1930's. Officially opened and dedicated in 1933, the Road was improved extensively between the 1930's and 1950's. Roughly 23 of the Road's 50 miles have been completely rebuilt in the last decade. However, these recent rehabilitation projects have been mostly on the lower portions of the Road, largely ignoring the highly sensitive and deterioration-prone alpine sections. As a result of continued roadway deterioration and inadequate maintenance and rehabilitation funding, the condition of the roadway is considered critical with respect to safety, serviceability, and retention of historical features.

Rehabilitation recommendations made attempt to take into account preservation of the historical features of the Road (see sidebar discussions throughout this chapter), as well as recognition of existing and projected traffic needs. The evaluations presented in this report are conceptual in nature, as is appropriate for this point in the evaluation, analysis, and design process. The information from this report will help establish alternatives for evaluation in an environmental impact statement (EIS). The result of the EIS process will be the identification of a preferred rehabilitation alternative. Only at that point will specific and detailed field investigation and design analysis begin.

Summary of Literature Review, Interviews, and Construction Plan Review

Existing engineering studies and reports were reviewed to determine the extent, completeness, timeliness, and usefulness of information available on the condition and needs of the Road. Twenty-four reports specified by the NPS were reviewed (see Appendix A for a complete list of the reports reviewed and the credentials of the reviewers). Also, personal interviews were conducted with various FHWA and NPS personnel, as well as private individuals. The purpose of the interviews was to glean as much information as possible from those most familiar with the Road, as well as to identify the current practices used for rehabilitation and maintenance of the Road. Construction plans for emergency rehabilitation projects currently occurring on the Road were also reviewed.

In general, the prior engineering reports reviewed evaluated the condition of the Road, inventoried and evaluated the condition of the retaining walls, and qualitatively described the drainage structure deficiencies along the Road. Several of the documents reviewed were simply summaries of field review meetings or correspondence sessions between personnel from the NPS and the FHWA.

From the review of available information it was concluded that no single document existed which clearly articulated and summarized the deficiencies of the roadway or the scope of rehabilitation planned for the Road. Further, nowhere was a description of the overall need for repairs and rehabilitation work clearly presented. None of the reports or documents reviewed evaluated alternative retaining wall types and/or alternative construction methods for wall rehabilitation. (The lack of documents on alternative retaining wall type is as a result of the Park's wall preservation focus.) In addition, there was no documentation of evaluation of innovative construction techniques. One report reviewed did evaluate the use of pre-cast concrete roadway elements as a way to accelerate construction.

During subsequent meetings with Glacier and FHWA staff, it was noted that several locations of pavement and structural distress had recently developed which were not evident upon completion of the previous engineering analysis. Consequently, these areas of distress were not included in any planning or cost estimates to date. Glacier staff further indicated that lack of adequate maintenance funding has led directly to some of the recent deterioration. Existing drainage structures and facilities are considered too few in number and only partially effective due to lack of adequate maintenance and placement. The issue of proper drainage control has been recognized by the FHWA and is considered essential to the long-range structural integrity of the Road.

Emergency repair plans and specifications for projects slated for construction in 2000 and 2001 were reviewed and found to adequately address the emergency needs at each site. A review of the detailed design reports for these projects was not conducted, as the projects appeared to be adequately addressed.

Specific FHWA plans for proposed project NPS PRA-GLAC 10(12) for repair of the failed masonry arch and damaged retaining wall at MP 24.56 were reviewed respective to the field reconnaissance findings. The proposed plans are considered accurate in detail and present viable, cost-effective solutions.

The recommendations that came out of the engineering literature review included the following:

- A detailed field reconnaissance review of the Road should be held to verify the condition of the Road as outlined in the work previously accomplished by FHWA and the park. During the reconnaissance the deficiencies and future needs of the Road should be identified and documented, including any not addressed by previous engineering studies.
- Alternatives should be developed for the rehabilitation of the Road which meet criteria set forth by the NPS. A constructibility workshop should be held with engineers, designers, and road building contractors to evaluate the alternatives developed.
- In order to accurately identify the location of historical guardwall, a cultural landscape inventory should be completed.
- Recommendations for the long-term operations and maintenance of the Road should be developed, current maintenance practices evaluated, state-of-the-art maintenance practices reviewed, and a maintenance workshop held.

The following findings further summarize the literature review:

- The general condition, location, and extent of damage to the existing walls has been analyzed and well documented. The MK Centennial team found no discrepancies between findings for the existing walls.
- Several sites were identified by FHWA as needing emergency repairs to correct structural deficiencies and maintain the integrity of the roadway. The field reconnaissance team later observed these sites, and the emergency nature of the repair requirements was confirmed. The NPS and FHWA are proceeding with detailed project design, plans, and work activities to address these needs, to the extent that funds are available.
- The focus of the existing studies and reports centered upon the short-term or emergency needs of the roadway, with little emphasis on long-term rehabilitation plans. This focus is consistent with the limitations imposed by the shortage of working capital.

- Twenty-two roadway sites are currently either funded or proposed for priority, emergency repairs. Design plans have been prepared for these sites by the FHWA.
- New sites and priorities have been identified in addition to the 22 sites noted above as other, previously hidden deficiencies have become evident.

Field Reconnaissance

MK Centennial team experts conducted a field reconnaissance and condition assessment of the Road during the week of August 28, 2000. During this reconnaissance, pertinent information was gathered to assist in determining the condition of the roadway, developing traffic management and engineering alternatives, and analyzing constructibility issues and the sufficiency of roadway maintenance. Visual observations were made to verify existing conditions and document deficiencies and rehabilitation options. These observations covered the general condition of the roadway, pavement, structures, drainage, fill sections, back slopes, and safety features. Also noted were contractor activities and traffic safety and management at two construction sites. These sites were the Loop dry stack wall rehabilitation at MP 23.93, and the avalanche-resistant wall project at MP 30.03.

Reconnaissance Team. MK Centennial's engineering reconnaissance team consisted of the following individuals. As a group, this team has 140 years of engineering experience since receiving their professional engineer’s licenses.

- Mr. Randy Ritchey, P.E., Team Leader and Structural Engineer
- Mr. Doug Weber, P.E., Chief Civil Engineer and Hydraulic Specialist
- Mr. Kay Hymas, P.E., Engineering Task Manager and Highway Engineer (design, safety, and general conditions)
- Ms. Nancy Dessenberger, P.E., Geotechnical Engineer
- Mr. Howard Tingley, P.E., Road Construction Specialist and Highway Engineer

Methods Used for Reconnaissance and Level of Detail. The general condition of the Road was observed visually with the intent of verifying existing conditions and documenting, in a broad sense, deficiencies and rehabilitation options. Field measurements were approximate (vehicle odometer, hand-held GPS receiver, pacing, measuring tape, etc.) and are considered adequate for the development of conceptual level traffic management and engineering alternatives.

Items of Specific Concern. During the field review special attention was paid to opportunities for innovative design, traffic management, and construction. The Project Team was particularly sensitive to issues of historic preservation, visitor experience, safety, practicality (design, construction, and future maintenance), socioeconomic impacts, roadway specifications, and construction alternatives.

Condition Assessment

The following sections present the findings of the field reconnaissance. Information is summarized on the existing condition of various roadway and roadside elements and recommendations are made to address general problems. These elements are grouped in the following categories:

- Roadbed and Pavement
- Structures
- Drainage
- Geotechnical Considerations
- Maintenance Issues
- Construction Traffic Management

Additional detail on specific items is provided in *Chapter 2: Engineering Analysis and Rehabilitation Alternatives*. Figure 2 (see page 13) is provided to assist the reader in determining the location of mile posts (MP) along the Road, as used in the following discussions. Locations of specific findings were documented in a Geographical Information System (GIS) format submitted to Glacier for incorporation in their GIS database.

Please refer to Appendix B where the location of specific findings are illustrated on roadway maps.

Roadbed and Pavement. The Road was originally constructed with a specification calling for four inches of 3/4 inch minus base course over top of four inches of 1 ½ inch minus sub-base, each sixteen feet wide. This material was compacted, without benefit of additional water, by driving the haul trucks over the placed material. Such an operation would have created additional fines within these two layers, which encourages drainage to seep through. As a result, excessive voids have occurred, with subsequent settling and failure of the roadway and shoulders.

During the field reconnaissance it was noted that the Road had been rehabilitated in the Lake McDonald section (western park entrance at MP 0.0 to MP 12.0), the Avalanche Creek section (MP 12.0 to MP 16.2), and the St. Mary section (MP 43.0 to MP 50.0) during the 1990's. These sections of roadway appear to be in good condition and should not require extensive rehabilitation at this time. Exceptions to this general finding include minor bank erosion, pavement slumps, and surface deterioration problems adjacent to Lake McDonald, and a roadway base subsidence in the vicinity of an active slide at MP 9.4.

Figure 3: Cracks reaching down into the roadbed.

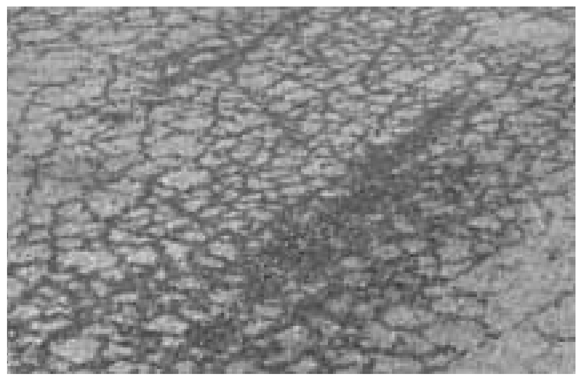

Figure 4: Alligator cracking

Various stages of road distress were noted throughout the remainder of the route (MP 16.2 to 43.0) including surface chipping, longitudinal and transverse cracking, rutting, shoulder raveling, shoulder and edge-of-road subsidence, alligator cracking, and surface treatment (patching) to correct for settlement. Figures 3 and 4 illustrate advanced stages of pavement distress encountered on the Road.

Road sections in rock cut areas are generally quite stable with only surface deterioration noted. There were some rock cut areas where concrete slabs had been placed in the road bed to stabilize the roadway (MP 28.5). While these slabs have improved stabilization to a certain degree, they have also resulted in cracks in the overlying asphalt at the edge of each slab. Further, some of the slabs have tilted resulting in edges of the slab showing through the asphalt. The proper solution to the problem in this area is to remove the concrete slabs and improve the drainage so that the roadway foundation is kept dry and stable.

Road sections through geotechnically unstable areas of colluvial deposits (for example MP 34.5 to 35.3) will likely require extensive stabilization and reconstruction work to correct structural and surface deficiencies.

Removal of existing asphalt and roadbed material will not have an adverse effect on features contributing to the historic designation of the Going-to-the-Sun Road. In fact, removal of removal of asphalt will be beneficial in some areas where excessive layers of asphalt have resulted in partial burial of significant guardwall and drainage features.

Due to the absence of a proper road base, many of the turnouts and parking areas are badly cracked and rutted or chipped.

Many of the shoulder areas are raveled and affected by erosion and weathering.

Many of the alpine and adjacent roadway sections are subject to subsidence of the outside lane, as noted by FHWA and verified by the MK Centennial team. Successive layers of asphalt pavement have been placed in many areas in an effort to maintain grade.

Appropriate repair of the areas outlined above will require removal of the existing failed asphalt; improved drainage where necessary to remove the unstabilizing force of water from the roadbed; potential removal of the roadbed material and replacement with correctly sized, placed, and compacted road base; and placement of new asphalt surface.

Structures. The field reconnaissance team examined the condition of existing stone retaining walls, stone guardwalls, guard rails, barriers, and bridges on the Road. Each of these are discussed in the following sections.

- ***Stone Retaining Walls.*** Free-standing mortared rubble (stone) walls on bedrock foundations are the predominant type of retaining wall along Going-to-the-Sun Road.

  Considering the age of these walls, they are in generally fair condition, with a few notable exceptions. These exceptions include five walls that are considered damaged beyond practical repair due to failed foundations, water intrusion, and stone displacement. These walls (listed below) will have to be rebuilt as described in the accompanying sidebar.

Also, the upper three to eight feet of many of the walls are in distress, with loose or missing stones and crumbling mortar. Almost all of the mortared walls exhibit some degree of joint and mortar deterioration; these walls should be re-pointed (the old mortar removed to the extent possible and replaced with new mortar). In many instances vegetation is growing in the mortar, which indicates soil contamination and moisture intrusion. The bottom portions of the walls are generally in fair condition.

The five retaining walls that are damaged beyond practical repair are listed below (MP numbers and wall dimensions are taken from the 1998 FHWA Wall Inspection Report Data Base). These walls must be rebuilt. This rebuilding can reuse the original stones to pre-serve the historic character of the walls.

Figure 5: Retaining wall at MP 27.58

MP 27.58 As shown in Figure 5, this wall (34 feet high and 160 feet long) has suffered signifi-cant lateral displacement, most likely due to

Repointing retaining walls will not have an adverse impact these historically significant features of the Road. Care and the highest level of craftsmanship should be used to ensure that the finished product will be indistinguishable from original mortar work. This will require either identifying and using the original mortar mixture and materials (the most historically accurate approach), or emulating the appearance of this mortar as closely as possible. When necessary, rebuilding the historic retaining walls will be acceptable from the perspective of preserving historic resources only if the wall is carefully disassembled and then reassembled with the same stone. The retaining walls must be reassembled exactly where they were originally (not in the location to which they have shifted), with no variation allowed in any direction - lateral, vertical, or horizontal. Use of concrete reinforcement would also be acceptable in a reassembled wall as long as it is totally concealed by the finished stone product and results in no displacement of the wall from its original position. Replacements for missing stones should be collected from existing scree slopes within the park. Stone veneered concrete retaining walls would not be acceptable.

subsurface saturation and poorly compacted subgrade. The mortar has been eroded from the rock masonry joints, and vegetation has taken root in the resultant cracks and crevices.

MP 32.95 to 33.0 The retaining wall and guardwall combination east of the East Tunnel portal (maximum height of 32 feet) has lost significant mortar from its joints, and is crumbling and failing in many locations. The roadway cross-section is being restricted at the peril of losing part of the traveled way, in addition to further loss of historic features. Repair and rehabilitation of existing retaining walls and guardwalls, as well as strategic construction of additional walls, is considered essential to the preservation of the roadway and historical features at this location.

In some cases, retaining walls and guardwalls can be added along the Road in areas where they did not historically exist without adversely effecting the historic nature of the Road. The recommended guardwall addition (MP 32.95 to 33.0) will actually replace a guardwall that once existed but has since been lost to time and deterioration. In order to restore this historic element and improve a section of roadway that badly needs help, a retaining wall will have to be constructed. Adding this retaining wall will have an effect on the historic nature of the Road; however, as long as it is constructed to emulate as closely as possible the nearby existing walls (materials, grout, color and placement of stones, workmanship, etc.) it will not be considered an adverse effect.

MP 23.42. 7.5 feet high and 51 feet long.

MP 23.47. 6 feet high and 44 feet long.

MP 23.655. 12 feet high and 23 feet long.

The recently reconstructed retaining walls with concrete cores in the Haystack Creek area appear to be in good condition. However, the visual appearance of these unfinished walls is in direct contrast to historic structures in the area.

At a few locations the original stones from retaining walls have been replaced with non-native Minnesota granite. Although these stones appear to be performing well, they present a significant departure in appearance from the original stone.

- ***Dry Stack Retaining Walls.*** Generally these walls were in good condition and functional, with the notable exception of the Loop retaining wall; which is currently under rehabilitation by FHWA.

- ***Stone Guardwalls.*** There are basically two designs: 1) roughly squared large stones laid flat in a more or less ashlar pattern, usually with large cap stones; and 2) rubble stones consisting of various sizes and shapes laid in a random pattern and usually without cap stones. In general, the ashlar walls are in better condition than the random rubble walls. This may be due in part to the following three factors: 1) random rubble walls appear to be constructed of a stone of lesser durability than the ashlar walls; 2) the random rubble walls have a higher proportion of mortar per stone than the ashlar walls, and thus are inherently weaker; and 3) without cap stones, the random rubble walls allow for more intrusion of moisture into the wall, which accelerates deterioration of the mortar and stone.

  The majority of the stone guardwalls are leaning away from the road or have been outwardly displaced from the roadway due to poor drainage and foundations, avalanche and snow weight pressures, poor maintenance practices, etc. Many have also settled. The general condition of these guardwalls is considered poor, and the repair and reconstruction of certain sections (such as at MP 32.95 to 33.0 listed above) is considered a **high priority**. Practically all of the guardwalls need repointing and other rehabilitation work.

  Many of the stone guardwalls have settled and/or their height has been encroached upon by pavement overlays or patching. This results in the wall not being high enough in many places to serve its intended purpose of keeping errant vehicles from leaving the roadway.

The discussion in the previous sidebar about repointing and rebuilding historic retaining walls also holds true for rebuilding historic guardwalls. Additional restrictions on the rebuilding of guardwalls include that the exact size (height, width, length) and location of the battlements (i.e. the “steps” that occur every so often) must be maintained; the exact type of guardwall be rebuilt (ashlar or random rubble); and capstones must be used or not used as appropriate to match the original guardwall. If necessary, a concrete footer may be built underneath the guardwall before it is rebuilt as long as it is totally concealed by the finished stone product and results in no displacement of the wall from its original position (lateral, vertical, or horizontal).

Figure 6: In some cases the distance from the top of the roadway to the top of the guardwall is as little as six inches.

Figure 7: Replacement mortar consisting of fine sand has almost no strength, and can be readily crumbled by hand.

In some cases the distance from the top of the roadway to the top of the guardwall is as little as six inches, (rather than 18 to 24 inches, as illustrated in Figure 6. Some of the stone guardwalls appear to have been reconstructed or repaired with a mortar consisting of fine sand, such as would be used for brick or concrete masonry work. As illustrated in Figure 7, this mortar has almost no strength, and can be readily crumbled by hand.

The original mortar was constructed of native sands and contains red and blue pebbles about one-eighth inch in diameter. In general the original mortar is in fair condition except for the surface joints which have been exposed to weathering. As mentioned previously, moss and other vegetation are growing on many mortar surfaces, contributing to the deterioration of the exposed surfaces.

- ***Stone Guardwalls on Concrete Foundations.*** At several locations the stone guard walls have been reconstructed on concrete foundations. These walls generally are not leaning and are not noticeably displaced horizontally.

- ***Removable Sawed Timber Rail and Steel Post on Concrete Foundation.*** These guardrails function as “removable” rails in avalanche zones and are generally in good condition (Figure 8); however, the FHWA has recently conducted a review of the crash worthiness of these systems and has concluded that they do not meet crash safety standards. These removable guard rail systems are non-historic. It is recommended that these guard rails be replaced. This replacement could be wood-veneered removable guardrail meeting crash-test and aesthetic requirements, or avalanche-resistant stone guardwall (see sidebar discussion).

- ***Non-historic Timber Log Rail and Posts.*** These barriers, which are in very good condition, are generally used to delineate the boundaries of parking areas, roadways, and driveways. They are not designed or intended to prevent errant vehicles from leaving the roadway.

- ***Large Barrier Rock.*** Large barrier rocks are used in many areas to delineate the edge of the roadway or parking areas (Figure 9). These barrier rocks are considered a hazard in that they do not offer a continuous

Figure 8: Removable sawed timber rail and steel post on concrete foundation is not historically acceptable, and does not meet FHWA crash safety standards.

The sawed timber rail and steel post removable guardrail is not historic and its use should not be proliferated. Because it is historically inaccurate, existing installations should be removed. An acceptable alternative, in historic stone guardwall locations, is avalanche-resistant stone guardwall. This is a concrete stem wall with stone veneer that looks like original guardwall. Round-log guardrail designs have been historically used in some other locations, the reuse of this design may be considered.

Figure 9: Large barrier rocks are generally being used to block vehicles, and are not historically accurate.

Figure 10: Temporary concrete "Jersey" Barriers replace missing guardwall, a dramatic visual departure from the original.

Barrier rocks are not historically accurate and are not desirable. Most have been added since the 1950's or 60's. They should be removed. In most areas their use is to block vehicles from informal pullouts. These pullouts were created in many cases by road maintenance activities that resulted in excess earth and rock material being deposited alongside the road, resulting in a wide spot near the road. The most historically correct action would be to remove the slide debris from alongside the Road and recontour the slope. Alternatively, the debris area could be revegetated. Either way, the informal pullout would no longer exist and the barrier rocks could be removed.

smooth transition through constricted areas, and may cause severe damage to impacting vehicles.

- ***Temporary Concrete Barriers.*** At several locations the original guardwall is missing and has been replaced with temporary precast concrete roadway barriers, commonly called Jersey Barriers (Figure 10). These non-historic barriers offer an effective interim measure for traffic control, though they do reduce available roadway width to a certain degree. Further, these barriers present a dramatic departure from the visual appearance of the Road. It is recommended that these barriers be replaced with historically accurate stone guradwalls.

  Installation of new guardwall should be considered at several potentially hazardous locations. An acceptable avalanche-resistant stone guardwall or round-log guard rail could be used in these cases.

Figure 11: MP 33.0, east of the East Tunnel

One candidate for replacement is located at MP 33.0 east of the East Tunnel, illustrated in Figure 11. At this location the hillside is encroaching into the roadway causing a narrowed road section where drivers attentions are already distracted due to the prominent roadside waterfall and the optical effect of driving out of the dark tunnel into the sunlight. An extension of the retaining wall and guardwall in this area would restore the original roadway width and provide protection for errant drivers.

All guardwalls observed had blunt terminals, which present a significant safety hazard to errant traffic. From an engineering perspective, this is generally undesirable; however, the blunt terminals have not been identified as an historic cause of accidents (see adjoining sidebar).

- ***Box Culverts and Bridges.*** Box culverts and bridges along the Road are generally in fair to good condition, though notably not well maintained. Cleaning and repointing of the rock walls of these structures is needed throughout the length of the Road, in addition to repairs to the base of box culverts such as at MP 21.25 (see Figure 12, pag 24). Rock and debris abrasion has eroded the bottom of these culverts to the degree that reinforcing steel has been exposed, promoting further deterioration.

The guardwalls are one of the primary contributing features to the designation of the Road as a National Historic Landmark. As such, they must be preserved with great diligence. The blunt ends of the walls have not been identified as an historical cause of vehicle accidents. Missing segments in existing guardwalls will likely be replaced during rehabilitation of the Road, resulting in fewer guardwall ends along the Road. Adding end treatments would unnecessarily affect the guardwalls' historic significance and should not be considered.

Figure 12: At MP 21.26, abrasion from rock and debris have eroded the bottom of the culvert, revealing the horizontal reinforcing bars.

The three bridge structures observed (Avalanche Creek at approximately MP 16.2; Sunrift Gorge (Baring Creek Bridge) at MP 39.0; and St. Mary River at MP 49.0) appeared to be structurally sound and generally in fair condition with the exception of some mortar and stone guardwall deterioration. The FHWA has identified a problem with the Baring Creek Bridge in that the stone masonry is potentially unstable due to subsurface water behind the abutment walls and loss of mortar. The FHWA has designed and scheduled a repair for this condition.

Repairing the base slab of the concrete box culverts presents no challenge to the historic character of the Road.

- ***Stone Arches.*** Most of the stone arches along the Road are in good condition except for minor to moderate mortar deterioration and weathering. One notable exception was observed at MP 24.56 just east of the Loop (Figures 13, 14, 15, and 16). Known as the Crystal Point Arch, it exhibits advanced stages of failure. A portion of the foundation of this arch has collapsed, resulting in a void

Figure 13: Crystal Point Arch at MP 24.56, just east of the Loop.

approximately three feet deep, six feet wide, and eight feet long directly under the traveled way. Further voids were found within the outside foundation of the arch. The pavement directly over this arch has settled significantly as a result of the loss of road base over the arch. This site has been identified by the FHWA for repair, and

Crystal Point Arch is considered one of the finest examples of workmanship and classic Going-to-the-Sun Road design anywhere in the park. As such, it must be treated with the greatest of care. The craftsmen who originally built this arch selected and placed each stone carefully to match the color and texture of the stones around it. For exceptional structures such as this, it is recommended that, should any disassembly be required, the stones be numbered when disassembled so that they can be placed back in the exact location and

Figure 14: A portion of the foundation of Crystal Point Arch has collapsed.

Figure 15: Corrugted metal culvert underneath Crystal Point Arch

Figure 16: A void has developed directly under the traveled way.

design plans have been completed for this work pending availability of funding (a copy of a portion of the plans is exhibited in Appendix D). Repair of this structure is considered **critical**. Disassembly of the arch will probably not be required for its repair.

- ***West Tunnel.*** No action is needed other than addressing rockfall issues and stone masonry repairs at the east portal and rockfall potential above the window vista near the tunnel's west end. Loose rock should be removed or stabilized in these areas as a safety consideration. Cracks in the tunnel lining appear well healed and are considered benign at this time.

- ***Triple Arches.*** Deteriorating supports and guardwall sections were observed at MP 29.8 (Triple Arches). As shown in Figure 17, emergency corrective action has been taken by FHWA to shore up the weakened bearing rock support columns. Although unsightly, this FHWA repair was effective. Additional stabilization efforts may be warranted in the near future to further shore up the structural bearing capacity of the retaining walls, adjacent rock stratum, and other structural elements, and to rehabilitate the guardwall sections.

Figure 17: At Triple Arches, MP 29.8, deteriorating suppports are shored up (detail below).

Figure 18: FHWA's emergency corrective action used steel I-beams to shore up the weakened bearing rock support columns.

Drainage. Discussions were held with Park Service personnel regarding areas of repeated debris accumulation and the difficulty experienced in removing this debris from drainage inlets and culverts. During these discussions and subsequent field reviews the following observations were documented.

- ***Divide Creek (East Entrance).*** The stream channel at this location (MP 48.5) has filled in significantly, subjecting the roadway and cross drainage structures (St. Mary River bridge and Divide Creek box culverts) to frequent flooding and bed load movement. The FHWA has completed a drainage assessment of this area which confirms these findings. Due to the extensive nature of the hydraulic problems at this site, a complete hydraulic and engineering study will be needed to determine appropriate corrective actions.

Figure 19: Rock and debris partially fill the entrance and interior of most corrugated metal culverts, inhibitiing drainage flow.

- ***Culverts.*** Most culvert crossings were generally in fair to good condition, with the exception of certain concrete box culverts which showed evidence of abrasion and deterioration as mentioned above. Corrugated metal pipe culverts appeared to be sound, with very little evidence of corrosion and only occasional incidents of abrasion. In some areas (particularly just west of Logan Pass) the drainage structures appear to be undersized for peak flow periods. Rock and other debris was observed partially blocking the entrance to several culverts and the interior of most culverts, inhibiting drainage flow as show in Figure 19. Removal of this debris should be made a top priority by the park.

  A few locations were noted where natural drainage flowed onto and across the Road as illustrated in Figure 20. Additional drainage culverts or properly placed cross drains would alleviate these problems.

Additional culverts may be added to the Road with no effect on its historic designation. The only restriction would be that added culverts would not impact the historic retaining walls.

Figure 20: In some areas natural drainage flows onto and across the Road. Additional culverts or cross drains woud alleviate these problems.

Figure 21: A roadside catch basin presents a hazard to vehicles.

Historically correct protection of roadside catch bsins would involve placing log barriers in front of the basins to block cars from them. These log barriers would be removed to facilitate snow plowing. Replacing these catch basins with drop inlets would not be acceptable.

The twin corrugated metal pipe (CMP) drainage crossing west of the Loop has partially failed. A pavement patch has been placed to fill the void created by the partial collapse. A new CMP is necessary to correct this deficiency.

- ***Roadway Ditches and Cross Drains.*** Drainage is generally conveyed along the edge of the roadway and into catch basins for dispersal. Catch Basins exist along the edge of the Road; however, many of these are not grated and, due to their proximity to the traveled way, pose a safety hazard (Figure 21). These catch basins should be modified to enhance vehicle safety.

Several drainage ditches and cross drains were choked with rock and debris, rendering them ineffective (Figure 22). Lack of detailed maintenance of these facilities was evident throughout the field review.

Rock wall drainage ports and roadside ditch drainage facilities were too few in number and poorly maintained.

Drainage in the Loop parking lot (MP 23.9) requires an outlet to evacuate standing water.

Refurbishment, maintenance, and the addition of necessary drainage facilities is considered a **high priority** throughout the length of the Road. Road damage resulting from water intrusion into the highway pavement and base was especially evident in the Alpine Section.

Figure 22: A cross drain is choked with debris, rendering it ineffective.

Geotechnical Considerations

- ***Avalanche Chutes.*** Avalanches are pervasive throughout the alpine area and continue to have an adverse affect on highway appurtenances. Debris flows have a significant impact on maintenance requirements and, potentially, roadway users.

- ***Slump Failures.*** Slump failures are generally limited to colluvium deposits and weakened fill sections adjacent to or underlying the roadway (Figures 23 and 24). Only a few notable slump areas were observed above the roadway. These appeared relatively stable at the time of this review; however, continued slow movements can be expected as a result of weather conditions and water intrusion. Slump failure areas should receive detailed analysis as part of future roadway design efforts. No specific recommendations can be made regarding these areas without geotechnical testing first being done.

Figure 23: Weakened fill underlying the road.

Figure 24: Weakened fill adjacent to the road.

- ***Slope Undercutting.*** Slope undercutting of the roadway occurs in both alpine sections and approach sections with steep side slopes. This condition contributes to the weakening or failure of guardwall and retaining wall foundations and to further constrictions of the roadway width.

  It is recommended that retaining walls, guardwalls, and roadway fill sections be restabilized through areas suffering from slope raveling and undercutting. Since erosion control is of paramount importance, roadway drainage should be directed away from side slopes that are subject to raveling by the use of culverts, flumes, lined ditches, or other means.

  Retaining wall and guardwall foundations should be strengthened and extended below the slope's angle of repose a minimum of two to three feet. Erosion resistant stone and/or matting should be placed at the top of the slopes to arrest slope raveling and undercutting. Retaining walls and guardwalls should be extended where necessary to re-establish roadway width and further protect the side slopes from erosion.

Figure 25: The most severe rockfall area is the quarter-mile section just west of Logan Pass.

- ***Unstable Slopes Above the Road.*** Unstable backslopes with potential landslides and rockfall hazards are considered a serious safety issue throughout most of the alpine section extending from about one mile west of the west tunnel (MP 22.3) to two miles east of Siyeh Bend (MP 36.2). The most severe “rockfall” section is the quarter mile section just west of Logan Pass, shown in Figure 25 (page 30). The Siyeh Creek and Haystack Creek areas are also affected by unstable back slope conditions and potentially hazardous rockfall occurrences. These inherently hazardous sections should be studied in detail, and mitigation measures should be undertaken in order to minimize these hazards. Mitigation measures could include scaling of loose or precariously perched rock formations, mechanical stabilization of back slopes, restrictive parking areas, etc. Historically hazardous sections should be monitored for progressive movements and/or escalation of hazardous conditions, and corrective actions taken as needed.

Public awareness of landslide and rockfall hazards should be amplified with additional signing, informational brochures, and other precautionary measures.

The scaling of specific rocks to eliminate specific rockfall hazards would be acceptable from a historic perspective. Scaling of rocks to improve horizontal or vertical roadway clearance would be unacceptable.

Maintenance Issues

Proper maintenance of the Road is imperative to protect capital investments, preserve the historic nature of the roadway, and enhance the visitor experience. It was noted during the field reconnaissance that most of the Road's facilities are suffering from lack of proper maintenance. Drainage structures are plugged with debris and have fallen into disrepair; guardwalls and retaining walls have crumbled and shifted; roadway and pavement sections have deteriorated with extensive cracking and slumping in certain areas, and rockfall and other potential hazards have been left unattended. The park has comprehensive operations and maintenance plans to address these issues; however, it does not have the financial means to carry out these plans. In conversations with GNP personnel it was indicated that approximately $200,000 was available for snow removal and maintenance of the Road in 2000; proper maintenance of the Road (once it is totally rehabilitated) is estimated in Chapter 3 as requiring between $1.48 and $1.93 million per year. Chapter 3 provides an extensive discussion of recommended maintenance practices and costs.
(Some damage to roadway facilities due to the shear weight and movement of snow and ice is unavoidable; however, current methodologies, equipment, and procedures utilized in snow and ice removal are very effective in minimizing further damage. Park Service personnel indicate that snow and ice removal procedures have dramatically improved over the past decade.)

Construction Traffic Management

Traffic management at the existing FHWA construction sites was well designed and staffed. Lane separation and delineation for one-way and two-way traffic was well marked and operational.

Traffic control at the Loop (MP 23.5) consisted of advance warning signs and individual lane delineation (two way traffic) past the construction site at the time of the reconnaissance. Single lane traffic, qualified traffic flaggers, and delays not to exceed fifteen minutes at a time were utilized as needed to accommodate contractor operations and facilitate traffic flow.

One-way alternating traffic control at the avalanche-resistant wall project in the vicinity of MP 30.03 was provided by qualified flaggers during construction activities and by temporary traffic signals at other times. Both systems were observed and found to be functional and effective. The maximum delay experienced at these sites during this review was five minutes per site (well under the prescribed maximum of fifteen minutes per site). Construction operations were proceeding in an effective manner as traffic was conveyed through the construction areas.

Comparison to Prior FHWA Condition Assessments

Engineering analysis and roadway condition assessments conducted by the FHWA were reviewed and compared with the findings of the MK Centennial team. The FHWA condition assessments covered the same issues with respect to safety, preservation of roadway features and historically significant roadway elements, and general maintenance operations. It was noted that the FHWA conditions assessments were thorough, accurate, and dynamic as assigned staff reviewed and updated roadway conditions on a regular basis.

The roadway deficiencies noted by the MK Centennial team were found to be very consistent with FHWA’s findings, especially with regard to pavement distress and rock wall failure and deterioration. The primary difference between the FHWA assessments and the MK Centennial assessment appeared to be the overall treatment of the drainage issue. FHWA has concentrated on immediate needs commensurate with available funding over the years, whereas MK Centennial gives added emphasis to long-term solutions respective to drainage, hydraulics, and roadway stabilization.

As a result of this comparison, the FHWA's condition assessment was verified as reported, and is considered substantially accurate. The priority roadway repairs identified by the FHWA (either underway or funded) were also verified.

Mapping

The findings of this condition assessment have been developed as an overlay to NPS-furnished GIS mapping. Additional GIS mapping is being developed by Glacier with input from the MK Centennial team, showing the locations of potential staging areas, avalanche chutes, roadway intersections, traffic pullouts, parking areas, guard-wall/rail termini, retaining wall termini, architectural features, drainage structures, and other pertinent information.

A map summarizing the roadway deficiencies and findings is included in Appendix B.

Conclusions, Recommendations, and Priorities

With the passage of time and the combination of severe weather, traffic, under-funded maintenance, and other contributing factors, the Going-to-the-Sun Road has fallen into a state of deterioration and disrepair. The integrity of the Road in contributing to a "world class visitor experience" for the traveling public has been compromised since the visual aspects and physical serviceability of the roadway have deteriorated significantly and are considered to be very poor at this time.

The field reconnaissance completed by MK Centennial has concluded that the majority of the Road is in need of extensive rehabilitation in order to be responsive to the issues of public safety, environmental concerns, socioeconomic impacts, transportation needs, and overall visitor experience. MK Centennial's recommendations <u>in order of priority</u> include the following:

- ***Emergency repair projects*** already under construction, or designed and slated for construction, are considered of the **highest priority** and should be completed accordingly**.** Due to safety considerations, the repair of the collapsed stone masonry arch at MP 24.56 (the Crystal Point Arch) is also considered **critical**.
- ***Repair/rehabilitation of the stone masonry guardwalls at MP 32.65*** adjacent to the east tunnel should be considered a **high priority** due to their deteriorated condition and the narrow confines of the roadway.
- ***Drainage correction and rehabilitation*** is a priority item throughout most sections of the Road.
- ***Maintenance of existing facilities*** (including rock scaling, drainage refurbishment, pavement crack sealing, etc.) is considered a **priority** in order to protect the historical and structural features of the Road.

- ***Roadway and pavement rehabilitation*** is required for approximately one-half of the roadway and associated parking areas. These locations are primarily from MP 16.2 to MP 43.05. Selective repairs and enhanced maintenance activities are also recommended over the remainder of the Road.
- ***Guardwall rehabilitation*** will be required on approximately two-thirds of the stone masonry guardwalls. All guardwalls should be examined and repointed as necessary.
- ***Stone masonry retaining walls*** should be rehabilitated and repointed as necessary. Five specific retaining walls should be reconstructed due to foundation failure and wall displacement. The top three to eight feet of many walls should be reconstructed due to advanced deterioration.
- ***Geotechnical concerns*** such as slumps, rockfall areas, unstable backslopes, etc. should be investigated and rehabilitated as necessary. Specific rock scaling operations should be considered from MP 28.5 to MP 28.6 to remove hazardous rocks and stabilize the rock backslope. Additional rockfall hazard signing should be installed to enhance public awareness.

Significant drainage considerations/corrections are required throughout most sections of the Going-to-the-Sun Road. These include, but are not limited to, the repair of damaged box culvert base slabs and wing walls, establishment of additional cross road drainage facilities, “weepholes” in stone wall structures, cleaning of rock and debris from drainage facilities and adjacent waterways, designing “maintenance friendly” drainage structures to facilitate cleaning and upkeep, interception of groundwater seepage into the roadway base and surface, etc. Drainage and safety (and in the case of the Going-to-the-Sun Road, historic preservation) are the controlling factors in good roadway design.

Initiate a short-term, interim maintenance activity to clean out and repair plugged and damaged drainage facilities. Existing maintenance management plans should be reviewed, modified as necessary, and supported with sufficient resources to monitor drainage facilities on a regular basis, and to take necessary action to keep drainage structures clean, structurally sound, and operative.

Glacier could establish a threshold of quality below which maintenance and preservation actions are considered inadequate. This threshold could then be used as a factor in developing maintenance funding requests. Elements could include needed equipment, personnel and training requirements, materials availability, and other factors specific to road maintenance.

A long-term maintenance program could be further developed, approved, and funded in order to preserve the integrity of Going-to-the-Sun Road, protect initial and subsequent investments, and enhance visitor experience. A significant outlay of funding is initially needed, possibly from a special allocation from funding authorities, or a private endowment. Creative financing is suggested as a way to supplement regular allocations. Possibilities include a vehicle/park usage surcharge assessed to visitors along with the normal park entrance fee, a public relations campaign to encourage public interest and donations for road upkeep and rehabilitation, local political and commercial support for maintenance needs, etc.

The review work performed for this chapter was intended to verify and/or perform basic roadway condition assessments and to provide information pertinent to developing feasible constructibility options, traffic management alternatives, roadway rehabilitation strategies, maintenance management options, and other conceptual engineering considerations. Analysis for this report was done at a conceptual level. Additional detailed and comprehensive field work (materials sampling, design survey, geotechnical analysis, etc.) and documentation (EIS, hydrology report, design report, etc.) beyond the scope of this task order will be necessary before site specific recommendations can be made or preliminary design of improvements can begin.

Putting "weepholes" in the existing walls is not historically acceptable where guardwall is in place on top of retaining wall, forming an unbroken plane of stone visible from outside the wall. Weepholes might be acceptable in areas where there is no retaining wall under the guardwall. These exceptions would require that the outlet be as unobtrusive as possible, including tilting the outlet down and skewing it to it is not parallel with the wall face and ensuring that the hole be made in a mortar joint, not in the face of a stone. Doing this would constitute an effect on the contributing nature of the wall, but not an adverse effect. Inlets and an underground storm sewer would be significantly preferable to weepholes. Another, less desirable approach would be a paved ditch to carry water on the cliff side of the road. Cleaning and maintaining the existing road drainage features would possibly eliminate the need for weepholes in most areas.